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BUILD YOUR OWN ROBOT: ASSEMBLING THE ARMS

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WIPEOUT VIDEOGAME

One integrated circuit equals ten action-packed games. Build this videogame and get in on that action.

L. STEVEN CHEAIRS

BY NOW, NO DOUBT, A NUMBER OF RADIO-Electronics' readers associate my name with video games. A fair portion of my articles thus far *have* dealt with that topic—and in the pursuit of the tradition, here is another one. This construction project will provide the reader with ten more black-and-white video games. Both NTSC and CCIR televisions sets may be used; NTSC is the standard 525-line U.S.A. system and CCIR is the 625-line system used in many foreign countries. Both single-player and two-player games are possible. On-screen automatic scoring has been provided.

Two potentiometers, one for each player, provide for vertical paddle motion. A control voltage, determined by the setting of the potentiometer, charges a capacitor; the charge-level of the capacitor is detected by a Schmitt trigger. Thus the rotation of the pot causes a variation in the voltage across the capacitor that is detected and translated to a player-position on the television screen. The player and his score are color-coded for easy identification. The audio circuit outputs tones to indicate hits of the ball by the player, and impacts with the court border or target obstacles. Game selection is made by using a 10-key switch matrix; either fixed—or momentary-contact—switches are acceptable. Two switches are used to start the ball into motion and to keep it in play during the game. A reset switch is provided to clear the screen to prepare for a new game. Three other switches select skill-level options.

About the games

Five single-player, and five dual-player games are contained on the LSI integrated circuit. Figure 1 shows a typical image for each game. There are three major types of game on that integrated circuit; those are *Wipeout*, *Color Squares*, and *Breakthrough*. The first four games that will be described are the wipeout games.

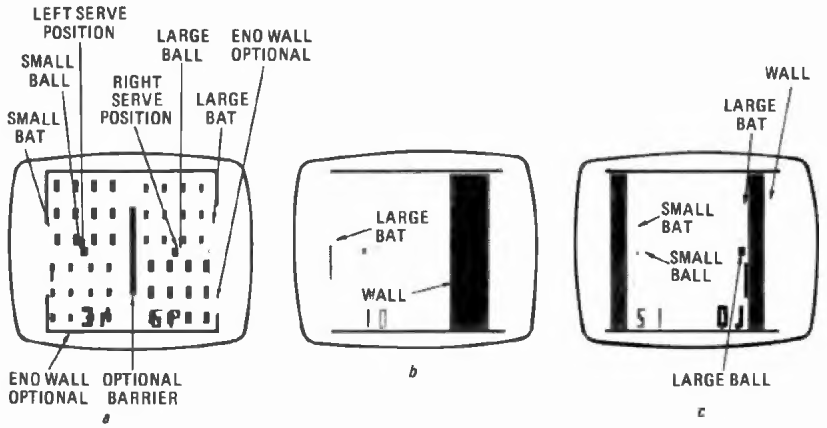
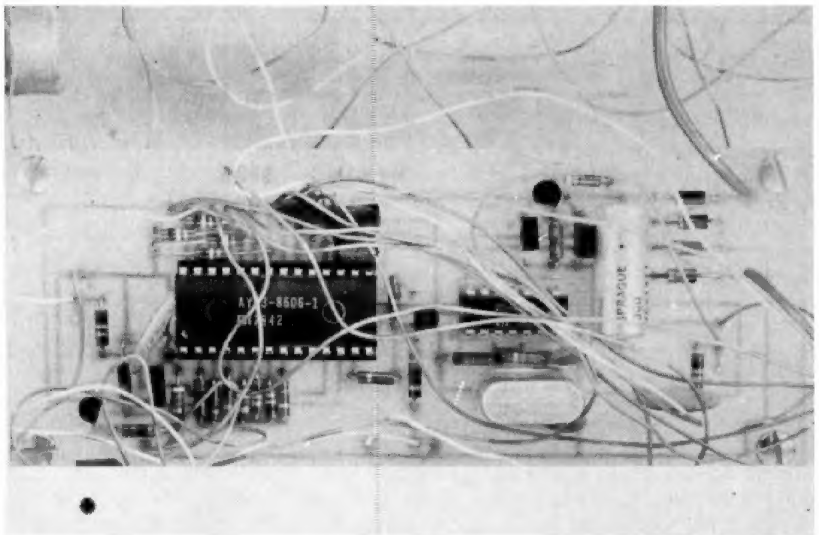


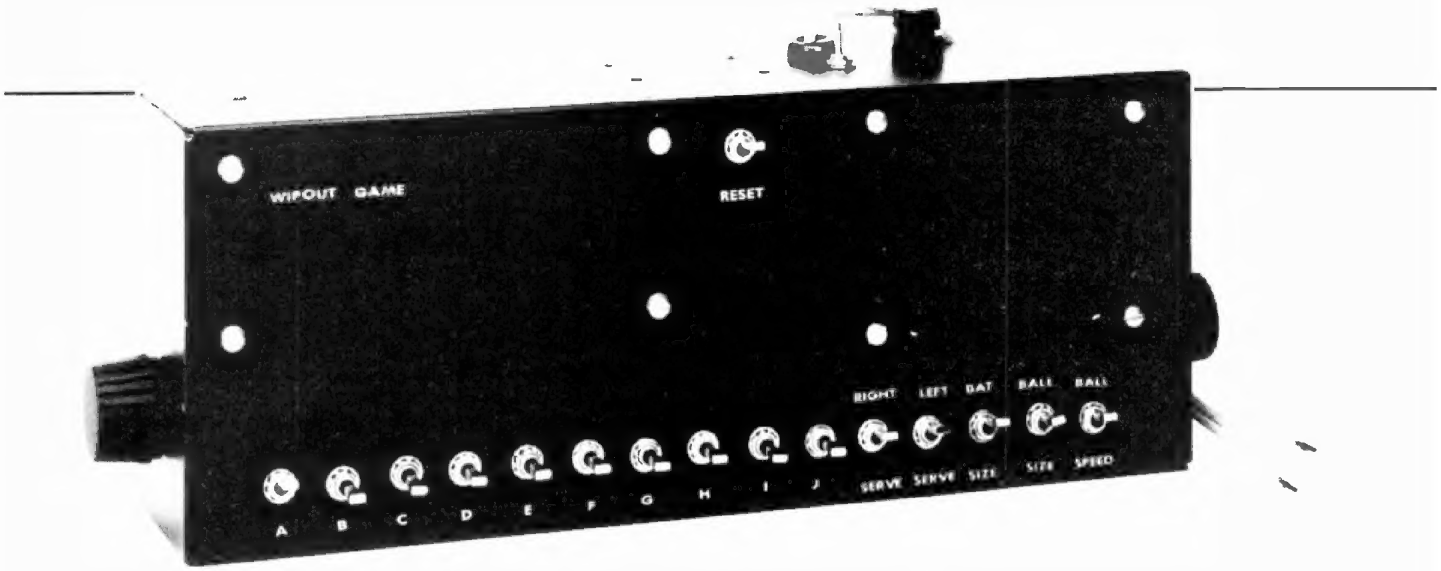
FIG. 1—VIDEO DISPLAYS used by the Ten Action Games. The variations for *Wipeout* and *Color Squares* are shown in *a*. *Breakthrough 1* and *2* appear in *b* and *c*.

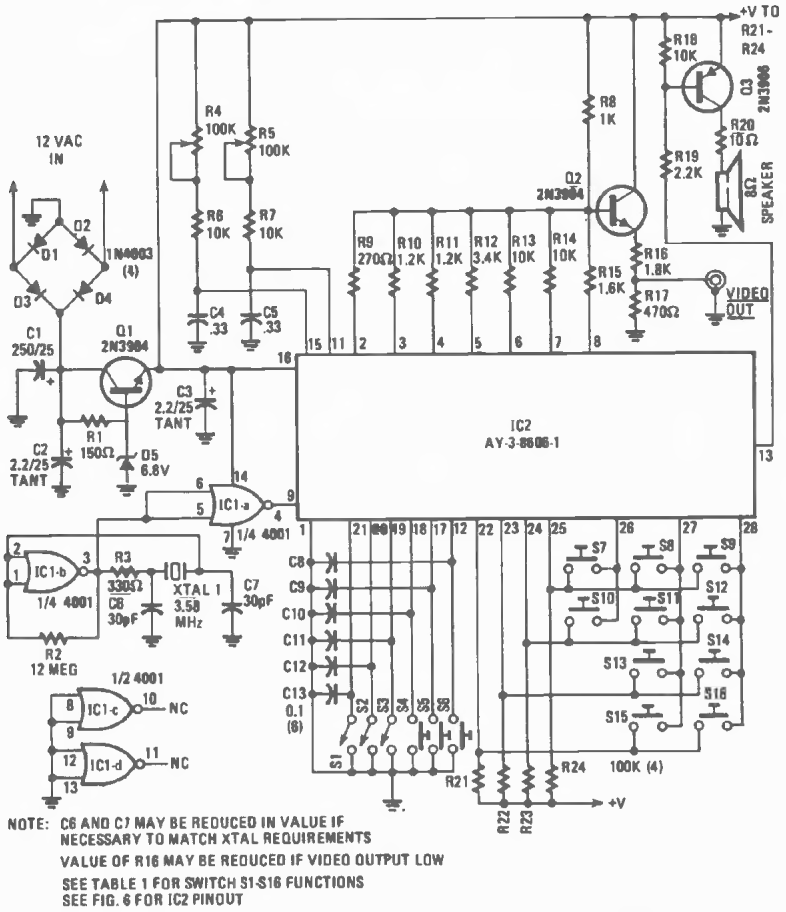
Figure 1-a illustrates the different characters that can be generated when playing the four versions of *Wipeout* and the four versions of *Color squares*.

Wipeout 1 is chosen when *select line one* and *strobe line one* are connected, either momentarily or continuously, by switch S9. After game selection and



THE HEART of the Ten Action Games board is the AY-3-8606-1 IC from General Instruments. Many of the components clustered around it are used to set the parameters of the games and display.





NOTE: C6 AND C7 MAY BE REDUCED IN VALUE IF NECESSARY TO MATCH XTAL REQUIREMENTS
VALUE OF R16 MAY BE REDUCED IF VIDEO OUTPUT LOW
SEE TABLE 1 FOR SWITCH S1-S16 FUNCTIONS
SEE FIG. 6 FOR IC2 PINOUT

FIG. 2—MAIN SCHEMATIC for the Ten Action Games. A foil pattern is provided in Fig. 4.

game reset, the game is started by pressing either the right or left SERVE button (S5 or S6). The object is to hit every black target-square. The squares disappear as they are hit. No deflection of the ball results from hitting a target-square. The game will end if five consecutive misses occur or if all squares are hit and obliterated. This is a single-player game—the right-hand paddle is used. That paddle is controlled by the pot connected nearest the LSI IC on the PC board. The score, paddle, ball, and boundary are gray. The score displays the number of targets hit.

Wipeout II is also a single-player game; it uses both the left and right paddles. After selection by S12 (*select 1* with *strobe 2*) and reset (S4), the game begins when either SERVE switch is depressed. It will start with a white ball moving toward the right side of the screen. If intercepted by the black paddle, the ball changes color to black and rebounds toward the white side. The color-coded score records the targets removed by its color ball.

If *select 1* and *strobe 3* are shorted together by switch S14, then *Wipeout III* is selected. It is a two-player game—both right and left potentiometers and SERVE buttons are used. The game is played much like the previous *Wipeout* game, but the playing area is totally enclosed. After the game is started it will continue until all target squares are removed. The first player to press his SERVE button after reset has control of the ball until his opponent can intercept it, thus gaining control of it for himself.

The last *Wipeout* game, *Wipeout IV*, is chosen by S16's connecting the *select 1* pin to the *strobe 4* pin. It is also a two-player game. The game is played generally the same way as the others but with one major distinction—the screen is divided by a large vertical barrier. Thus the ball can only cross the field near the very top or bottom of the image and an added set of player strategies is gained. For example, once the ball is on a player's side, it may continually be bounced off the barrier to gain up to half the possible points. To win then, one need only pass the ball to the other side of the playing field. At least one more point will be scored in doing so, winning the game.

Color Squares games follow similar lines to the *Wipeout* set with one major exception—the screen is divided into four sections. Two quadrants are color coded as the white player's and two are color coded as the black player's. Target destruction may only occur by ramming one's own color square. The game ends when all targets of one color are removed. *Color Squares I*, selected by connecting *select 2* to *strobe 1* (S8), is a single-player game. *Color Squares*

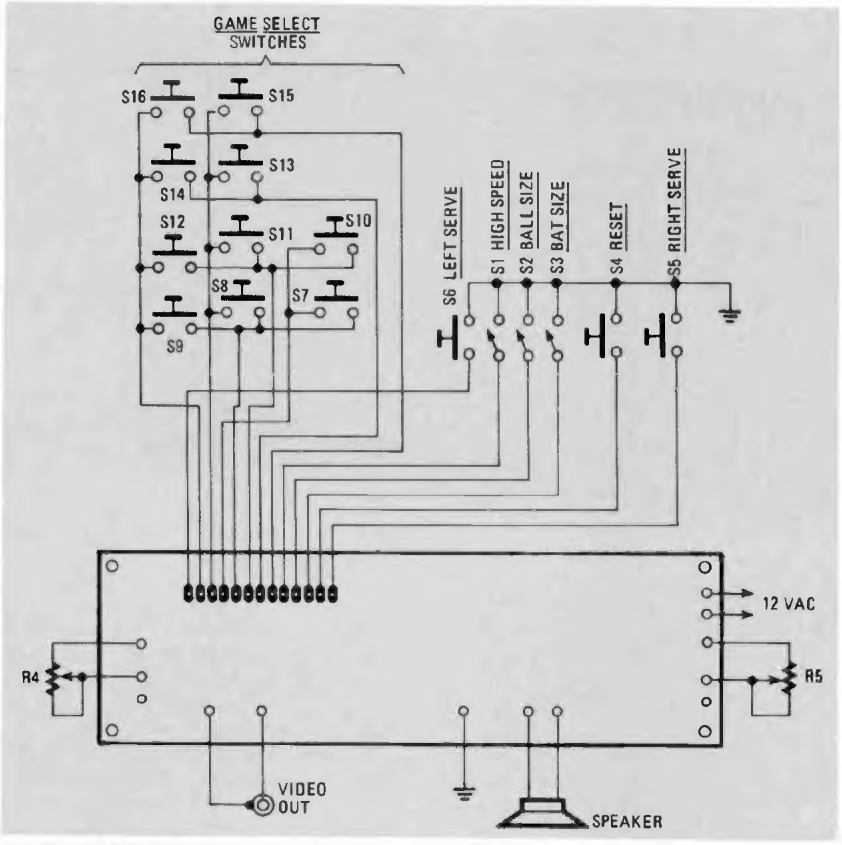


FIG. 3—CONNECTION of case-mounted components to main PC board.

TABLE I		
Switch No.	**Function**	**Pin No's.**
S1	High speed	21, Gnd.
S2	Ball size	20, Gnd.
S3	Bat size	19, Gnd.
S4	Reset	18, Gnd.
S5	Right serve	17, Gnd.
S6	Left serve	12, Gnd.
S7	Breakthrough I	25, 26
S8	Color Squares I	25, 27
S9	Wipeout I	25, 28
S10	Breakthrough II	24, 26
S11	Color Squares II	24, 27
S12	Wipeout II	24, 28
S13	Color Squares III	23, 27
S14	Wipeout III	23, 28
S15	Color Squares IV	22, 27
S16	Wipeout IV	22, 28

II is similar, but is a two-player version (it uses S11 to connect *select 2* and *strobe 2*). *Color Squares III (select 2* and *strobe 3*—using S13) is played much like *Wipeout IV*. *Select 2* and *strobe 4* (S15) turn on *Color Squares IV*. That is a single-player game, with only one paddle; the field is enclosed on three sides.

The remaining two games are *Breakthrough I* and *Breakthrough II*. *Breakthrough I* (Fig. 1-b) is a single-player game selected by switch S7. The ball is served toward the wall opposite the player's paddle. When it hits the wall a block is knocked out. The object of the game is to knock a hole through the wall and then to pass the ball through the hole. Each time the ball knocks a block from the wall it rebounds. The paddle is maneuvered to intercept the ball and redirect it into the wall. The wall is nine layers thick; only seven misses are permitted. The score, which should be kept as low as possible, records the number of blocks removed.

Breakthrough II (Fig. 1-c) is a two-player game with walls that are four layers thick. The game ends when a breakthrough occurs. Winning is a function of the number of hits. That game is turned on by the *select 3* pin and the *strobe 2* line (S10). No game selection occurs when *select 3* or *4* are shorted to *strobe 3*.

Some features are common to all the games. The targets are arranged in a 4×6 array. Each target is eight raster lines high and four dots wide. The score display is sixteen lines high and six dots wide. Each vertical line is two dots wide and each horizontal line is four raster-lines thick. The ball can be either of two sizes, five lines or nine lines high—switch S2—and the bat size and ball speed are selected by S3 and S1, respectively. The audio signals are the same for all the games.

Construction

This project is relatively simple for the beginner. But, even so, a minimum level of skill in construction is assumed. There are a number of sources (such as back issues of **Radio-Electronics**) where the beginner can find information on construction techniques.

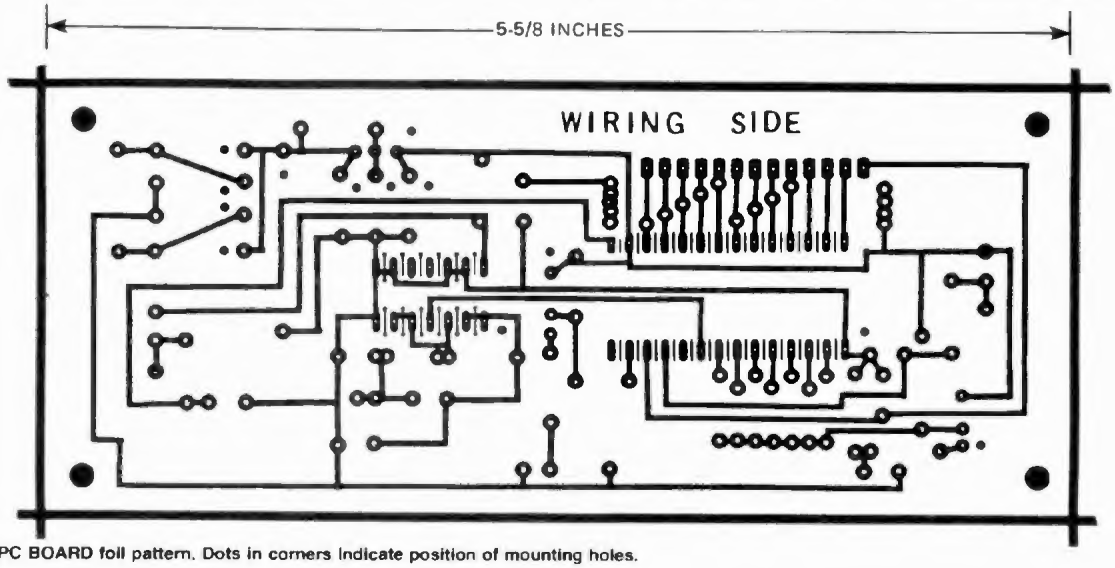


FIG. 4—PC BOARD foil pattern. Dots in corners indicate position of mounting holes.

PARTS LIST

All resistors ¼ watt, 5% unless otherwise specified

Resistors
R1—150 ohms
R2—12 megohms
R3—220 ohms
R4, R5—100,000 ohm pot, linear taper
R6, R7, R13, R14, R18—10,000 ohms
R8—1000 ohms
R9—270 ohms
R10, R11—1200 ohms
R12—3400 ohms
R15—1600 ohms
R16—1800 ohms
R17—470 ohms
R19—2200 ohms
R20—10 ohms
R21-R24—100,000 ohms

Capacitors
C1—250 μF, 25 volt electrolytic
C2, C3—2.2 μF, 25 volt tantalum
C4, C5—0.33 μF ceramic
C6, C7—30 pF ceramic
C8-C13—0.1 μF ceramic

Semiconductors
D1-D4—1N4003
D5—6.8-volt Zener diode
Q1—2N3904
Q3—2N3906
IC1—4001 CMOS quad, 2-input, NOR gate
IC2—AY-3-8606-1 (General Instruments) for U.S.-standard video (525-line) or AY-3-8606 for 625-line standard
XTAL1—3.579545-MHz crystal
S1-S3—SPST toggle switch
S4-S16—SPST normally-open (N.O.) pushbutton switch
T1—12-volt, 1-amp transformer

Miscellaneous: case, 8-ohm speaker, line cord, output jack, four spacers, wire, hardware.

The following may be obtained from Quest-Star Electronics Co., 5412 Burntwood Way, Las Vegas, NE 89108: Kit with all parts (no case or hardware), U.S. standard, G1300, $55.00 or 625-line standard, G1301, $57.00. PC board only, $12.00. AY-3-8606 or AY-3-8606-1, $14.50. For orders of 25 or more contact Quest-Star for prices. Please add $2.25 for shipping—any excess will be refunded. Nevada residents add 3½% tax. Shipment will be made from stock to six weeks.

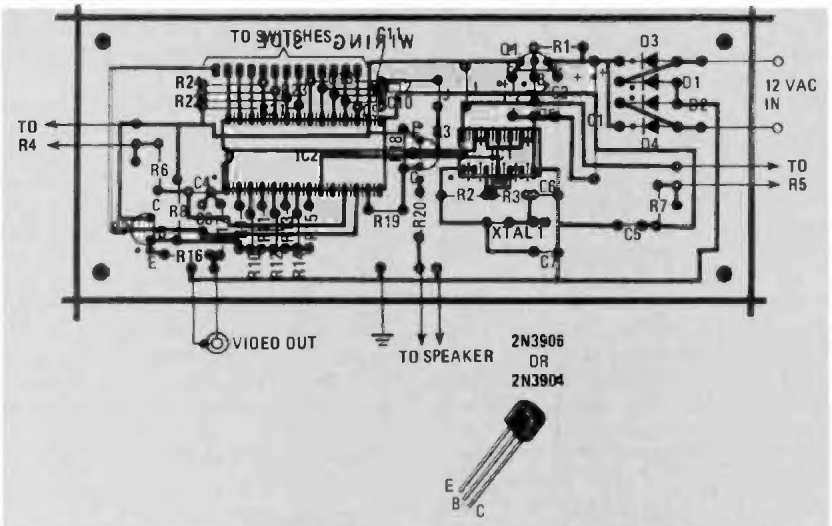
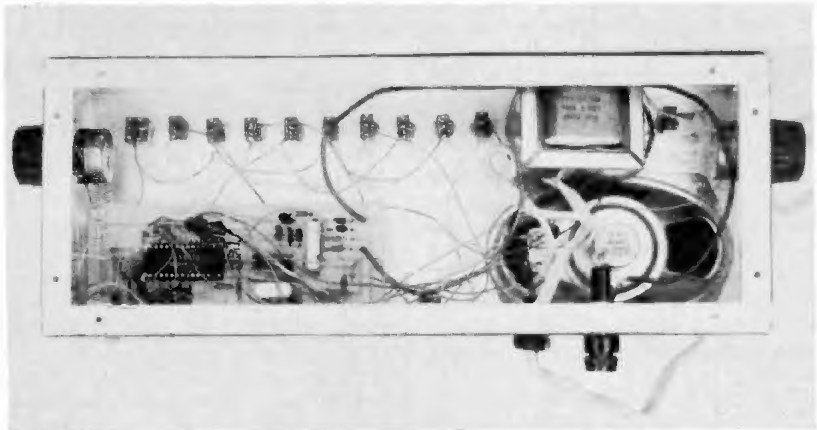


FIG. 5—PARTS PLACEMENT DIAGRAM. Take care to observe all polarities and make sure that jumpers are installed. Do not confuse the 2N3904 and 2N3906 transistors.



SUGGESTED LAYOUT for the PC board and external components within the case. The array of switches at the top is connected to a row of pads located just above the game IC.

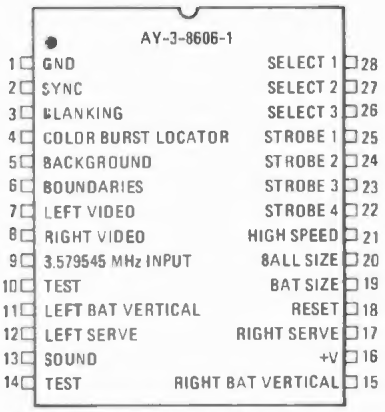


FIG. 6—FUNCTIONAL PINOUT of the AY-3-8606-1 IC. This can help you with the off-the-board wiring and, should it prove necessary, in troubleshooting.

The basic tools one will need are a fine-tip, low-wattage soldering iron (about 27½ watts), a pair of fine-tip pointed-nose pliers, a pair of diagonal-tip wire cutters, and a set of wire strippers. Also, include a spool of rosin-core solder. The game, may be assembled using point-to-point wiring, wire-wrap, or printed-circuit techniques. The printed-circuit approach will be considered here. The other two methods can be undertaken using the parts list and the schematic diagrams shown in Figs. 2 and 3. Table I lists the functions of the front-panel mounted switches and their connections.

If the printed-circuit approach is chosen then one can etch his own card using the artwork pattern presented in Fig. 4, or a board layout may be made by referencing the schematic diagram. The simplest course is to buy a ready-made circuit board from the source given in the parts list, Quest-Star Electronics Co.

The first step is to obtain all of the components shown in the parts list; most of those are common items. The main LSI game IC may be a bit difficult to find, but it might be obtained from the same source as the PC board. Also, Quest-Star will provide a complete kit of *all* parts for those who do not have access to all of the components or who want to simplify their shopping. The complete kit includes all of the electronic components, the PC board, and the required hardware.

Having collected all of the parts, place all of the electronic components on a workbench, desk, or table. Make sure that all of the MOS and CMOS integrated circuits remain in their conductive packaging. Compare the components, now laid out, to the items specified in the parts list and if everything matches then proceed.

Take the enclosure and drill the holes required for the potentiometers, switches, transformer, PC board,

speaker, video-output jack, and line-cord. Next, paint the exterior of the case. After the paint is dry use dry-transfer lettering to label the controls. That should be followed by spraying the case with a clear lacquer to protect the finish. Let the case dry for 12-24 hours.

Mount the corner spacers on the foil side of the printed-circuit board. Install the IC sockets in their proper locations—making sure they are oriented properly; Fig. 5 should be consulted. Place a piece of cardboard on top of the sockets and invert the assembly, keeping an even pressure on both sides. Now solder the sockets into place. Return the assembly to the components-side up position.

Install all of the resistors and capacitors; verify their locations and solder. Next install the diodes, transistors, and voltage regulator. Again verify the orientation and placement of the parts before soldering. Lay the PC card aside until final assembly.

When the case is dry, mount the controls, transformer, line-card, output jack, speaker, and PC card. Wire those components as shown in Fig. 3. Before proceeding verify the wiring! Plug the line cord into an AC wall outlet. Check the voltages at the IC +V pins for the proper DC level—about 5 volts. If they are correct, unplug the cord and discharge the capacitors. Install the IC's in their sockets—observing the proper orientation. The assembly is now complete; if an RF modulator is to be used it may be also installed in the case.

Troubleshooting

This section, I hope, will never be needed but if problems should be encountered use the schematic diagram and the pinouts provided in Fig. 6 to aid in troubleshooting the game circuit. Start by following the checklist below:

1. Are all components in the proper location?
2. Are all components oriented correctly?
3. Is the PC card wired correctly to the external components?
4. Is the power-supply voltage correct?
5. Is a 3.58-MHz clock signal present at pin 9 of the game IC?
6. Is there an audio output?
7. Is there a composite video signal?

If the answer to any of these questions is "no," then investigate that portion of the circuit. For example, if no clock signal is observed, check the oscillator. Troubleshooting in that fashion should enable you to locate and remedy any problems rather quickly.

You should obtain a great deal of enjoyment from both the construction and use of this project. R-E

VIDEO

TROUBLESHOOTING VHS TRANSPORT CIRCUITS

FOREST BELT

THE VHS VIDEOTAPE TRANSPORT MECHANISM is a complex one, and so are the electronic circuits that control it. Let's take a look at how those control circuits work.

A prime key to the operation of the control circuitry lies among several switches. They open and close at what may seem irregular times during the tape-threading process. But the timing is quite specific, as you will see.

Actually, only two switches (see Fig. 1) work oddly. They operate as follows: While the machine is in the STOP mode—that is, before any button is depressed—the play-1 switch is open, and the play-2 switch is closed. When you first press down the PLAY button, the play-1 switch closes. The play-2 switch remains closed, for that initial movement of the PLAY button. However, by the time the PLAY button reaches the bottom of its travel and latches, the play-2 switch has opened.

Later, pressing the STOP button unlatches the PLAY button. As the play linkage leaves the latched-down play position, the linkage closes the play-2 switch . . . and shortly thereafter opens the play-1 switch.

The switches just described initiate the loading operation. To shut off the threading motor when loading has reached its limit, a loading-end switch closes and applies 12 volts to transistor Q612. The switch, having closed when loading is finished, remains closed until the motion of loading actually begins.

Unloading is initiated whenever the PLAY button unlatches, whether it is done manually or by the auto-shutoff solenoid. As you already know, this action of the PLAY-button linkage closes the play-2 switch and opens the play-1 switch.

Then, when unloading is completed, the unload-end switch closes. That grounds the cathode side of diodes D617 and D618, which redirects voltages around so the motor quits running. The unload-end switch stays closed until such time as the PLAY button again starts a loading operation.

In one variation appearing in recent VHS models, the loading-end switch closes a path to ground instead of to a voltage supply. Of course, circuitry changes somewhat. For operation of the remainder of the section, however, that modification changes practically nothing.

Tape loading

To initiate tape loading, the operator depresses the PLAY button on the front of the machine. Switch play-1 (see Fig. 1) closes immediately. When the button is first pushed, switch play-2 remains closed.

A DC voltage goes through the play-1 switch to a voltage divider (R633-R634) at the base of Q611. That turns Q611 on. The voltage at the collector of Q611 goes low. In digital terms, logic high at the base of Q611 produces a logic low at the collector—a classic inverter action. The low voltage (logic) coupled to the base of Q610 through R632 places a logic high at the Q610 collector and a logic low at its emitter. Both are output points from that stage.

Low bias at the base of Q609 leaves Q609 cut off. A logic high could develop at the collector if there were some path for DC from a supply point. As